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EFFICIENCY OF A NEW METHOD FOR MAKING CERAMIC ARTICLES WITH A FUSED-DROP PATTERN

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A new method for making ceramic articles with a fused-drop pattern is offered. The technological process of producing facing tiles with a "lunar surface" pattern created by fused drops is considered. The technological process is simplified, and the production cost of the tiles reduced.

The state of the surface of a ceramic product is very important and determines the product quality [1]. This is true of both glazed and nonglazed articles. That is why in producing, for example, facing ceramic tiles special attention is paid to the surface glazing technology and the state of the glazed surface, since the state of the surface affects the glaze thickness and consumption, the tile exterior, and consumer qualities.

Until recently, some tile factories in Russia and Ukraine made only monochromatic facing tiles, for example, of white color. However, contemporary decoration of buildings and interiors calls for a coloristic solution to exterior and interior decoration. This has promoted the production of a wide range of tiles decorated in different ways [2].

Thus, the Slavyansk Ceramics Works uses a method of decoration by splashing glaze of various colors, which produces a marble-like coating, i.e., a coating with a fused-drop pattern. The latter is widely used and enjoys great demand.

This pattern is made in the following way. Two groups of glazing mechanisms are installed along the technological production line. The first is designed for coating the tile facing surface with a glaze suspension, and the second one is used to deposit drops, for example, of the same glaze suspension. Figure 1*a* depicts a tile fragment with a fused-drop pattern. The tile is coated with a glaze layer, and the drops of the pattern are arranged on top of that layer. The thickness of the main glaze layer is on the average 0.37 mm, and the drop height is 3.00 – 0.17 mm. The drops of the pattern have an irregular shape and are arranged randomly. In the course of tile firing, the drops become fused and create a special decorative effect.

The seeming simplicity of this method for producing tiles with a fused-drop pattern has a substantial effect on the cost of tile production, because substantial quantities of expensive suspension are consumed and additional mechanisms are involved to form the drops and deposit them on the tile surface.

This process is elemental and not controllable and depends on the technical state of the drop-forming devices. Furthermore, there is no distinctive pattern of fused drops: there may be too many or too few drops, which is actually the case after technical maintenance of the devices and at the start and end of their operation.

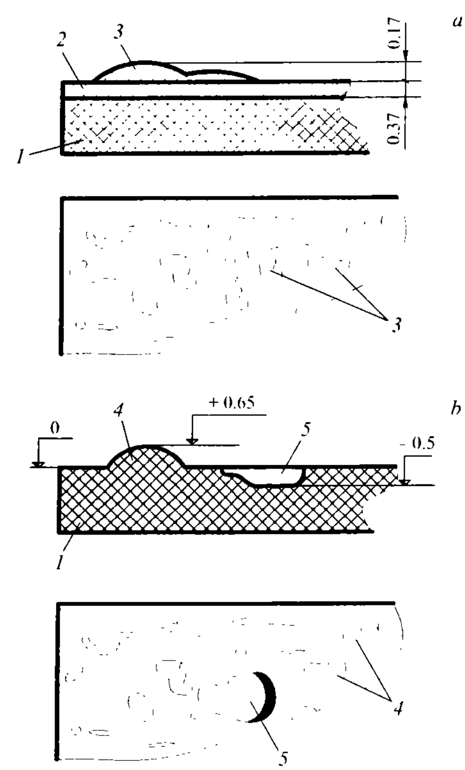

Fig. 1. Tile fragment with a fused-drop pattern (*a*) and with the semi-finished pattern (*b*): *1*) tile; *2*) main glaze layer; *3*) drops; *4*) protrusion; *5*) depression.

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Taking into account the tile construction and the favorable flow properties of finely disperse ceramic molding mixtures, we developed a new waste-free technology for production of ceramic tiles with a fused-drop pattern. A semi-finished pattern is produced simultaneously with the molding, using the molded-article material, for instance, ceramic molding powder (the patent authority of Ukraine has made a decision to issue a patent on application 98084593).

For this purpose, a sample of an industrial tile ($150 \times 150 \times 5$ mm, GOST 6141–91) with the most successful configuration and arrangement of drops was selected. A tile blueprint was made with a pattern that could be specularly transferred to the working surface of the upper die of the press, for instance, by machining.

A comparative analysis of the tiles and the working (molding) surfaces of the dies revealed significant distinctions, i.e., before the proposed method was used, the tiles were smooth with a high grade of surface finish, while the new tiles have a rough surface consisting of protuberances and depressions interrelated by a three-coordinate system (length, width, height). The rough surface of the tile is formed in a four-coordinate system (where time is the fourth coordinate) and is effected in the deformation zone by impressing the die projections into the molded tile and simultaneous filling the die depressions with the molded material. The degree of conformity of the resulting relief of the tile facing surface with the die working surface is determined by the forces and kinematic parameters of the deformation zone. The indicated parameters, in turn, are determined by a large number of regular and random factors, frequently interrelated. All this suggests considering the deformation zone as a complex system whose function consists in transformation of the three-coordinate working surface of the die into the three-coordinate facing surface of the tile.

The classical principles of material treatment theory are not suitable for calculation of such systems, and analytical solutions with an acceptable degree of complexity of the mathematical procedures result in a large error due to the large number of simplifications and assumptions.

Apart from theoretical studies, experimental design work was performed to improve the die construction or, more precisely, the fused-drop pattern and the die working surface. The improvement of the die included:

– adjustment of the dimensions and configuration of the drop-forming elements;

– alteration of the fused-drop pattern by making depressions in the tile and the corresponding projections in the die working surface;

– accomplishing a smooth transition of the drop-forming elements from the die surface, etc.

The upgraded die was installed in the die holder of a KRU-160 hydraulic press with a maximum pressure force of 16 kN. Production of experimental tile batches was carried out on the production line of the NIIstroikeramika Institute, switching off the second group of glazing devices designed to form drops and deposit them on the tile face surface. The work was performed at the Slavyansk Ceramics Works using the main and auxiliary production materials. The granulometric composition of the molding powder: was 0.5% grain content with a particle size down to 1.0 mm; 5.0% from 1.0 to 0.5 mm; 72.5% from 0.5 to 0.2 mm; 22.0% below 0.2 mm. The density of the glaze suspension was 1.53 g/cm^3.

The drying and firing conditions corresponded to the technological regulations of producing glazed ceramic tiles for interior wall decoration.

A fragment of a tile molded according to the new method is depicted in Fig. 1*b*. By taking the face surface of the (unglazed) tile as reference level 0, a projection is located above this level (+ 0.65), and a depression is located below this level (– 0.5). The latter is a novel element in tile design. This generated a new pattern variant that was called "lunar surface." Other original fused-drop patterns were called "slanting rain" and "starry sky."

The proposed method for ceramic-tile production opens wide possibilities for producing articles with new fused-drop patterns. It is possible to control pattern creation by varying the size, shape, and arrangement of the drops. Preliminary calculations of the economic efficiency of the new method show that the cost of producing facing tile at the Slavyansk Works has decreased by 25% due to the decreased consumption of the glaze suspension, which costs 10 times more than the molding powder. Furthermore, the technological process is simplified, and machinery and equipment items are released from service.

Thus, application of the proposed method for ceramic-tile production makes it possible to optimize production costs, constantly respond to changing consumer demand, and increase the competitiveness of the product.

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